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ABSTRACT

The meaning of cost-benefit (c-b) studies, advocated with increasing frequency as a remedy for the ills that beset education, is explained, the difficulties that exist in transfering the c-b techniques of business and defense to education are outlined, and specific pioneering c-b studies, particularly those aimed at evaluating new instructional media, are reviewed in this paper. The overall conclusion reached is that meaningful c-b analysis in the most important areas of education is not feasible until a scientific base on educational processes has been established. (SP)

Cost-Benefits: A Buyers Guide for Instructional Technology

by Richard E. Speagle*

Urgency of Efficiency Studies

Today's crisis in education, like that in medicine and other social services but greater in severity, is brought on very largely by production problems. If agriculture had as little expertise in how to produce and process its major crops as the educational establishment has with respect to teaching and learning, half the world would be starving.

But schools are different from farms. Any farmer who cannot raise grain or cattle economically will go broke. People would refuse to buy his substandard produce when he brought it to market.

The young student does not have that choice. His local school enjoys close to a monopoly on education. Moreover, bolstered by direct taxing powers, the school need not go bankrupt, no matter how inefficient. It can shift the spectre of bankruptcy to the hapless parent by assessing him to the hilt. No wonder taxpayers revolt.

To urge educators to apply businesslike methods is not advocating regimentation and the assembly line. The call is for a modern managerial approach to the school's basic production activity, the teaching-learning transaction. Whether mass lectures or individual tutorials are the indicated mode of instruction cannot be decided until one has analyzed, the way a successful manufacturer analyzes, the effectiveness and cost of each alternative.

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Some visionaries dream about the advent of new technologies in education without being aware of the path by which technology, step by step, has conquered and continues to conquer other fields of Western culture. These steps are scientific and economic. Scientifically, technology has been the victor by virtue of a clear, research-based showing than it could perform old tasks better, and tackle new ones never before within the reach of man. Economically, technology has convinced the doubters by giving hard-headed, dollars-and-cents proof of its greater productivity, making use of increasingly sophisticated systems analysis, operations research, and cost-benefit techniques. To believe that technology can force its way into the school without a similar comprehensive effort is to close one's eyes to the evidence.

The sad truth is that managerial information and methods do not yet exist in education except in minute or experimental quantities. Education has been miserly in its research and development expenditures and, unlike health or medicine, has budgeted funds for R&D with an eyedropper. That a multibillion dollar industry like education should be lacking the fundamental data to conduct its affairs in an economical, cost-effective fashion is nothing less than an outrage and an underlying reason for campus rebellion.

This chapter sets out to do the following:

I. Explain the common sense meaning of cost-benefit (c-b) studies, advocated with increasing frequency as a powerful remedy for education's ills.

II. Outline the difficulties that exist in transfering the c-b techniques of business and defense to education.

III. Review specific pioneering c-b studies, particularly those aimed at evaluating new instructional media.

Before proceeding, it may be well to state the overall conclusion: meaningful c-b analysis in the most important areas of education is not feasible until a scientific data base on educational processes has been established. What can be done now are comparative cost studies, but they omit one-half of the equation, the benefit or output side. These benefits, in systems language, cover the primary mission of an educational enterprise: to improve the accuracy, speed and completeness of information flows to its student clientele for translation into learning.

I. Meaning of the Term Cost-Benefit

"Getting the most learning for the least money" is the way some pragmatists frame the basic problem of education in a world of scarce resources -- a brief imperative that succinctly states what c-b analysis is trying to accomplish. On a simpler but familiar plane, a bargain-hunting housewife shopping in a supermarket, who reads the fine print on every box and compares the contents with the price, is a rudimentary type of c-b analyst.

Educators by contrast often herald some bright new idea and enthusiastically urge its universal adoption, without being able to measure the benefits or saying much about additional costs. An illustration is a scheme used in the Army, called "Instructional System Development Steps." It lists six stages in the design of courses such as Mechanical Principles, Electric Theory, or Applied Aerodynamics:

1. Collect job data and analyse.
2. State training objectives.
3. Design: content, method, media
4. Construct course
5. Field test (includes evaluation).
6. Implement.

The first five steps actually comprise a feasibility study. They tell whether the proposed course can be taught effectively in the desired fashion, for instance through programed instruction. From step five to step six however there is a jump -- from "can do" to "let's do it" -- without any specific analysis of costs. Military educators sometimes share a shortcoming with civilian school administrators, and overlook monetary constraints.

Some academicians draw a line between cost-<u>benefit</u> and cost-<u>effectiveness</u> analysis but this distinction is readily disposed of here. Benefit is the wider concept. It includes effectiveness, which may be measured concretely in dollars, bushels, or valid test scores. But, in addition, benefit also comprises aspects like enjoyment or recreation, deeply felt but defiant of precise quantification.

Since schooling aims at such intangible outcomes as art appreciation and civic consciousness, as well as at such "bread and butter" objectives as job training, the benefit terminology seems more appropriate. One may still talk freely and interchangeably about effectiveness whenever the discussion gets around to the "hard," measurable kinds of output.

<u>Efficiency</u>, despite its similar sound, is another concept: it is the relation between output and resource input. A given cost-benefit ratio is a practical measure of efficiency.

If indeed a semester of learning algebra were comparable to a box of cereal, and a course of English composition were as uncomplicated a product as a rib roast, c-b decisions in a school district would be a "breeze." Administrators would quickly reach for the instructional "package" promising, in combination, the largest quantity and the best quality per unit price. Even this would not relieve them, first, of having to define "quality" and, second, of balancing -- in the jargon, "trading-off" -- quality against quantity of instruction when the school budget was tight.

To add to the complexity, the school purchases not a standard product but a bundle of services, with multiple objectives in mind. The same complexity arises when a new health program is put into effect or when NASA tries to make a rational choice among multiple ways and practical means of putting a man on the moon.

C-b analysis as applied to productive processes is a feat of a far higher order of magnitude than is "comparison-shopping" at the meat counter, analagous in objectives though the two may be. To cope with this step-up in analytic difficulty resort has been had to systems theory and analysis, discussed in a separate chapter. Among the closely related operations research tools, formalized c-b analysis has proved to be one of the most prominent and useful.

The present discussion will concentrate on c-b analysis applied to the instructional phase of education, with particular emphasis on the evaluation of the new teaching media. However, the same general c-b techniques are perfectly adaptable to school administration and operating decisions where they are a lot simpler to apply.

Indeed the rationale of c-b analysis is most plausibly explained in a business setting. The following four central steps are typically involved in "cost-benefitting" a business project, such as opening a new branch office:

(a) Defining the objectives, with profit expectations occupying a prominent place.

(b) Costing out various alternatives, refering to size and type of store, location, market served, staffing, pattern of projected growth, and the like.

(c) Determining the benefits of each alternative "bundle of options" analyzed in (b).

(d) Relating the <u>benefits</u> of (c) to the <u>costs</u> of (b), and finally choosing the most efficient alternative -- that with the highest ratio of benefits to cost.

This skeleton outline looks like a straight-forward business proposition of calculating the rate of return on a prospective investment. Actually it is still a rather simplistic version, such as one uses to initiate college undergraduates in the c-b approach. In real life, numerous important side conditions and

constraints are at work, derivable from systems thinking, which color the businessman's branch decision:

--Are there nonmonetary and indirect benefits, like larger market shares, personal prestige for owners and management, justification for higher staff salaries, a better image in the public mind?

--Is executive and skilled manpower available for an expanded business?

--Can funds be obtained on the terms desired?

--How will conpetitors react and what will be their countermoves?

--Will there be new problems in organization, internal communication, warehousing and transportation?

--Will the promise of growth motivate existing personnel and attract new employees of high caliber?

II. Cost-Benefit Analysis in Education

C-b based decisions obviously cannot be ground out mechanically by formula. Most factors moreover are not predictable with certainty, but must be weighed according to some estimated probabilities. Educators face all these hurdles of business and "then some," summarized under the previous four standard stages of c-b analysis:

(1) Objectives: The taxonomy of educational objectives is exceedingly complex; measures and goals are difficult to define at all levels of the school -- total curriculum, grade, course, lesson, and block of study.

(2) Costs: Costs of instruction are crudely measurable in terms of teacher and materials inputs; the pricing of new media rests either on an experimental scale or on projections whose value is limited by highly restrictive assumptions.

(3) Benefits: The pecuniary benefits of education are roughly measurable by future income differences but nonmonetary benefits resist measurement; the learning output of students is only imperfectly quantified by achievement tests.

(4) Rate of Return: A monetary return on cost, or investment in education at any level is roughly measurable when compared with no education at all; c-b comparisons among instructional alternatives, as offered by the new media, remain feasible in theory only.

(1) Objectives

The great commitment of society to education shows up in the wide spectrum of goals that schools are asked to pursue. Considerable progress has been made in indentifying and categorizing these goals into such major breakdowns as the cognitive, affective and volitional domains. A wealth of subclassifications support this taxonomy.

Objectives may differ for each separate course of study to distinguish it from the others, but they all have a common denominator: to change the potentialities, proficiencies and attitudes of students who communicate in the instructional process.

It is important to stress the close connection between goals and measurement. The profession of a goal is meaningless unless one can at least tell whether one's distance from the goal has widened or narrowed. As a minimum, one must know "how well one is doing" in accomplishing an objective.

Successively more demanding requirements would be that one be able to sense one's direction of movement relative to the goal, be able to measure both distance and speed in moving toward or away from the goal, and be able to specify and rank means of reaching the goal.

The ultimate purpose of c-b analysis is to find an optimal solution through an appropriate ranking of alternative courses of action. Therefore the operationally most useful objectives are those whose attainment, expressed in outputs or realized benefits,

may be measured cardinally, along a continuous scale. Considerably less useful are objectives that permit only an ordinal ranking of their benefits. No wonder that c-b analysis emphasizes objectives that are easily quantifiable over those that are "fuzzy."

Critics of "progressive" education sometimes charge it with a naive passion for testing and measurement. C-b analysts would answer that educators are prone to reject efforts at evaluating their activities. If a given course of study is designed to stimulate "creativity" or "intellectual curiosity" there must be a way to identify these qualities. Else one is merely talking in an echo chamber.

(2) Costs

Perhaps the easiest phase of data collection for educational c-b analysis is the cost part. Conventional budget and accounting figures abound, even if administrators often mutter about the lack of management information. What they would like to have is: data properly classified to predict the impact of higher admissions on instructional space and faculty needs; further breakdowns by type of classroom, subject, and staff; and finally a propagation of definite patterns for future years, based on past attrition and transfer rates. Maintaining records in the

necessary detail and categories costs money of course. Program accounting is different from conventional fiduciary accounting. While some institutions have adopted a program approach, most schools would rather spend any disposable funds on tangibles, like brick and mortar or scholarships.

Raw accounting data can lead the unwary analyst to simplistic ways of measuring school input. A smart factory superintendent knows not only the number but also the quality of his men and, with an eye on productivity, pays them accordingly. The major variable in teacher compensation seems to be not quality but seniority and passing through advanced courses organized mainly to produce automatic pay raises. The gifted teacher, measured admittedly by unscientific standards, is many time paid no more, and perhaps less, that the rest if he happens to be an innovator who "rocks the boat."

As for the materials input in the school, cost analysis is no better and probably worse. The annual bill for physical facilities, like science and language laboratories, gets folded into total costs without reference to degree and intensity of use. In industry, by contrast, inputs of plant and equipment are firmly controlled by a benchmark of performance, "standard costs". These shoot up sharply when the utilization rate falls below a desired percentage of capacity. Management is alerted and usually takes prompt action. At some levels of c-b analysis, like that concerning the economic benefits of higher education, the value of student income forgone through school attendance must be considered a cost input.

(3) Benefits and their Measurement

Measures of educational output or benefits -- the two terms will be used here as stand-ins for one another -- range from the global down to the minute and highly specific. At the top end of the scale, output may mean success in reaching a desired "capacity of reasoning" and "social sensitivity," and at the bottom end, ease of handling the multiplication table.

The difficulties of measuring output are mainly two:

(1) An outright lack, or inadequacy of suitable yardsticks. In part this problem refers to the quality and validity of educational testing.

(2) The joint-product nature of educational output. A prosaic analogy are ham, tallow, and pork bellies, unobtainable in isolation and forthcoming solely in various mixes, depending on the individual hog.

Educational yardsticks come a cropper when they try to measure such ambiguous objectives as "acculturation to societal values." Are educators talking about opening up for students free choices within the framework of the Constitution and its supporting documents, or do they mean brainwashing them to promote conformance with endorsed community values? In either case, the learning output would consist of a change in attitudinal variables, which are notoriously nettlesome to define and measure. However, an attitudinal index scale, based on the expert judgement of psychologists

and sociologists, could probably rate students before and after exposure to a given curriculum. Opinion polls too might find a useful niche. A successful test for output might show more positive attitudes toward books and learning among the underprivileged, "turned-off" students of the ghetto schools.

Undeniably, great progress has been made in refining test procedures and scores in national programs. The same cannot be said for "mini-tests" such as quizzes, midterms and final examinations, not to mention term-papers. These do exceedingly well if they manage to establish a fair ranking of students that justifies a course grade. Such sloppy testing would never do in serious research on the output of particular instructional processes.

The joint-product aspect of the educational enterprise makes a general evaluation of effectiveness problematic. In principle, one would first test students for various subjects and attitudes. Second, one would weight, and third combine the separate academic outcomes in some acceptable fashion -- probably a composite index.

The hog butcher obtains the value of the animal by pricing each cut of meat, multiplying it by the quantity, and adding up the components. School procedures can never be that uncomplicated but conceivably a consensus could be reached on how to value good citizenship relative to a mastery of the differential calculus. The problem of finding an optimum mix of educational objectives

and of allocating budget resources accordingly constitutes a Pandora's box that is best left unopened in the present context.

A word of caution must be added about the proper use of test scores in c-b analysis. Except perhaps in kindergarten, students do not enter a course totally ignorant of the prospective subject matter. What counts therefore is not their test performance on the final day of school but improvement over a pre-entrance test base -- the before-and-after increment in test scores.

This idea is the equivalent, in industrial terms, of value-added in manufacturing: the difference between a firm's sale price of its product and the cost of raw and semi-finished materials purchased on the outside. Scholastically one could speak of "value-added" as the difference between "student output" over initial or pre-entrance "student input."

This approach is already used in evaluating education by student earning power. On an overall or "macro" level of analysis, a Cabinet official may want to know whether a given training program is worth its cost in dollar terms, apart from intangible cultural benefits. If the annual outlay for a specific Job Corps Center equaled the additional future earnings of participants for a reasonable number of years ahead, the project would at least break even from a national interest viewpoint. Alternatively, if the tax revenues generated by these additional earnings managed to match the budget cost of the annual program, the project

would break even from a fiscal viewpoint. These statements abstract from such complications as discounted cash flows, opportunity costs and other technical aspects of capital budgeting.

C-b tools can be applied -- some practically right now and others as yet only potentially -- at various levels of an educational system. Consider a two-year nursing program in a junior college where the president may want to ask these critical questions:

Level	C-b Question
(i) Overall program	What additional earning power do graduates enjoy over and above their expected income if they had only a high school diploma?
(ii) First-year curriculum	What measurable difference in learning achievement, relative to cost, would it make to add, drop or change a specific course?
(iii) Biology course	What differences in learning and cost would result from substituting programed instruction for one quarter of the scheduled lectures?
(iv) Lesson in anatomy of frog	What difference in test scores, compared with the cost, would ITV make if substituted for the second hour of lecture?

Some analysts like to add such yardsticks as school attendance and drop-out rates to measure program output. Yet merely warming a seat in some lecture hall is not student-output but input. Student truancy and drop-out rates, if reflecting changes from some earlier base, might serve as proxies for changes in attitude and motivation. An improvement in attendance rates between senior and freshman year might be considered part of the educational output of the high school, indicating greater acceptance of achievement as a part of the American value system.

(4) Rate of Return: Technical Cost-Benefit Ratios

The message of the foregoing is clear: in the absence of adequate cost and output figures no proper c-b ratio can be calculated. In some determinate areas, like skill training, it appears perfectly plausible to construct a ratio, by putting the new-learning output of a course in the numerator and its corresponding dollar cost in the denominator. But this ease of solution is deceptive. It fails to carry over into more complex, multipurpose learning situations.

The practitioner of c-b techniques must solve two related problems in sequence:

(1) How to properly match input and output.

(2) How to choose among competing alternatives available to do a job.

Up to this point, one major problem of c-b analysis in the educational enterprise has not been squarely faced: the prerequisite of appropriately matching the inputs and outputs of productive processes if useful results are to be obtained. One must know which resources cause what learning effects.

Take the example of a one-semester course, French I, upon completion of which the student is tested for language skills. Assume further that motivation is acknowledged to be a critical factor in learning; that appreciation of French literature, not ignoring its racier aspects, furnishes an excellent incentive to learning; and that certain classic and modern French writings are skillfully built into the content of the course. Obviously, facility with the language in this case is not the sum total of student learning. If a deep interest in French culture has been aroused, the motivation may carry over into advanced courses in French, into other languages, into history, and possibly into a course in poetry. Thus there are multiple outputs, spilling over from the supposedly limited learning objective of a foreign language, which must be caught by the evaluator.

On the input side, "direct labor and materials" expended on a course are easily identified. But assume an imaginative chairman of the romance languages department has ordered a special list of French books and magazines for the library. Further he has organized an exciting exhibition of French motion pictures,

not restricted to Joan of Arc, the Cayeux tapestries and the production of Requefort cheese. How are these costs to be allocated to French I?

The answer divides into several parts. To begin with, input and output do not match at the specific French I level. Rather outputs correspond to inputs only at a much higher educational plane, perhaps French studies or even liberal arts. Thus c-b analysis conducted for a small part of the curriculum makes little sense because output cannot be attributed simply and directly to the input processes.

This should not prevent the teacher from testing learning output in French I or in small segments of the course, like irregular verbs. But such partial testing constitutes something different, quality control. Industry makes extensive use of such controls all along the production line, without infringing on the managerial use of c-b techniques.

C-b analysis has an important time dimension that should not be lost sight of. Assume a school official wanted to know whether teaching French I with the aide of a new language laboratory was more "cost-beneficial" than conventional methods. A pertinent question he might ask would be how long it took the average student under either mode to reach a certain proficiency in reading and conversation. This would keep learning output constant and focus only the difference in cost. A cost reduction

by one-half could then be interpreted as a doubling of teaching efficiency through the "language lab" medium.

The Place of C-B Techniques in a Systems Approach

In the logical sequence of systems-analytic steps, c-b techniques enter at a relatively late point. As a pre-condition they require that production alternatives be clearly identified and labelled feasible. They must be shown to "work" and to produce some measurable output, otherwise any costing exercise is futile.

In Greek mythology, Paris was confronted with three feasible choices in women: wisdom, power and beauty. On a benefit basis Helen looked like a winner until the cost was revealed in the Trojan war.

In industry, c-b routines are widely used in capital budgeting. Their basis is the process information furnished by the line departments -- engineering, production, traffic, sales and the like-- and the inputs of each process are costed out accordingly. If any vital details of the operation are insufficiently known -- say the metallurgy of a particular ore deposit or the recovery of a catalyst in a chemical process -- feasibility studies must be conducted to gather this information. Such studies are inputs for any complete c-b analysis of alternative mining or manufacturing opportunities.

In the school, the search for alternatives -- for better ways of doing an education job -- necessarily involves the design of experiments in the teaching-learning transaction. For example, as new media in instructional technology present themselves, they should be tested scientifically to see what they can do. Each medium should be given trials separately and in combination with others, discipline by discipline. The experiments should be based on carefully thought-out hypotheses on just how the medium enters into learning processes. Preliminary results should be fed back to formulate still more promising hypotheses for the next round of experimentation.

In this fashion the chain would run -- apart from information feedbacks flowing "upstream" -- from fundamental research in learning theory down to applied research and farther "downstream" to feasibility studies of new media. The latter should generate a large set of instructional possibilities, to serve as the basis for the final step in decision-making, a c-b based choice of an optimum learning pattern.

This system-inspired sequence of steps for progress in education plainly shows that c-b analysis is no panacea. A faddist clamor for greater employment of this technique as a cure-all confuses the issue and scrambles priorities. That is why responsible researchers confine their work to theoretical models while waiting for a valid base of useful data sometime in the future.

In the meantime, a workable technique is that of cost comparisons. It is less powerful because it deals only with the cost side on instruction. Educational outputs or benefits are treated as constants, under the tacit proviso that little is understood as yet about learning processes. Hopeful speculation about improvements in teaching performance through the use of new media is kept on a low key. Comparative cost analysis is the tool applied in this Study in the chapter on media costs.

III. Two Meanings of C-B Analysis: A Review of Recent Work

Just as systems analysis taken as a whole has two meanings, as noted in the respective chapter, so logically do any of its parts like c-b techniques. One meaning would define c-b analysis as the writing of instructions in a prescriptive or "how-to-do-it" sense. This type of activity is also known as "model-building." It constructs a conceptual mock-up or scale model of the actual analysis to be performed at some later time.

In its second meaning, c-b analysis means going ahead and applying a particular prescription to a practical situation. An example would be formulating a decision whether to put library materials on miniature slides known as microfiche, or whether to keep the old system of books-on-shelves.

Up to now, and understandably in the absence of scientific information about what happens in "instruction," c-b analysis has

confined itself to "recipe writing." Theoretical models of various kinds, but belonging to the same general family, have been elaborated. For one thing, they specify some of the data that an educational c-b analyst needs and how he is to use them if and when they become available.

As another characteristic, the models apply to whole institutions or general programs rather than the working classroom where instructional alternatives need to be tested. At that critical level yawns a vacuum even of theories of instruction so that c-b analysis is virtually out of the question.

The model-builders recognize their inability to tell:

Who..

Should teach what...

To whom...

Through what means...

In what sort of environment...

With what effects.

They know full well that in education the customer literally does not know what his dollar will buy and lacks a consumer's guide to tell him. Time and again authors explicitly disclaim any ability to choose among instructional patterns and disavow any attempt to measure instructional effectiveness. Regretfully they address their c-b studies to what <u>is</u> rather than what <u>should be</u>.

Model A

Some c-b models are preliminary blueprints that apply to particular skill training activities, like the Job Corps Centers organized by the Office of Economic Opportunity. One researcher limits his consideration of benefits to exactly eight possibilities which range from Outcome 1, a 30-day drop-out that spells failure, to Outcome 8, defined as graduation and successful job placement. He then compares various Centers, using for his purposes a set of symbolic equations that relate inputs and outputs. Finally he proposes mathematical rules that would enable a program director at least to rank various Centers and identify the most effective ones by their relation between "successes" and total costs.

The author also puts his ideas to work on accounting records covering four closed-down Men's Urban Training Centers, with promising results. It should be stressed, however, that his c-b analysis employs extremely crude measures of inputs and outputs. The study never descends to the critical level of the teaching-learning situtation where the effectiveness of new media must be demonstrated. The reason again is obvious: adequate information does not exist.

Model B

Other models, besides providing more detailed specifications of benefits, aim for absolute rather than rank-order c-b ratios. That is, they want to measure costs and benefit directly rather than content themselves with saying that "Brand A" school is better

than "Brand B." One such model, which attempts to evaluate Title I programs under the U.S. Elementary and Secondary Education Act, measures four educational inputs and four outputs as follows:

Element	Measurement
Inputs	
Quantity of instruction	Class duration;
Quality of instruction	Recency of curriculum materials;
Intensity of instruction	Teacher-student ratios; teaching materials per student;
Teacher quality	Education and degrees; teaching experience.
Outputs	
Student achievement	Course grades;
Learning attitudes	Drop-out and truancy rates;
Earning potential	Expected increase in lifetime earnings;
Equality of educational opportunity	Scholastic achievement becoming less dependent on socioeconomic level of student.

These elements of an input-output matrix only faintly approach what a scientifically-designed experiment needs to compare a programed text with a teacher-aided drill section, to name a

typical example. Here too the author of the model is forced to accept the conventional classroom scenario as given, without delving into the basic question of what produces learning. This particular scheme, at the cost of some heroic simplications, ties its diverse elements into a complete package of equations, diagrammed and reasonably ready for the computer.

Model C

One large-scale type of c-b study has been proposed to determine the effectiveness of various conventional inputs at the school level against outputs measured by Iowa test scores. Statistical multiple-regression techniques would be applied to something like 500 schools to identify physical input-output relationships in education. For example, such a study would try to check the effects of higher teacher salaries, thought to imply a better quality of instructor, on average test scores.

A school system might use such results to conclude that raising salaries (after allowing for a lag of time) would raise teaching productivity at member institutions. A similar analysis would be performed on other causal variables representing school characteristics, like the pupil-teacher ratio or an index of academic quality. The massive data requirements of such a scheme, and the large and coarse input units to which it is scaled, make it unsuited for pilot studies let alone classroom experimentation in new teaching media. Even at its own level, on extensive study

based on this model proved to be unwieldy and produced indifferent results.

Model D

Still another model design provides the cost accounting framework for a detailed comparison between computer-assisted and conventional instruction in a public school. This model comes equipped with elaborate flow charts and is based on highly flexible modular units. That last feature makes it adaptable to many different levels, instructional media and organizational situations. If actual accounting data were fitted into the slots prescribed by the model, a computer could analyze and rank any two or more teaching alternatives according to benefits gained and costs incurred.

In a concrete case, if it were desired to compare the present operation of a New York City high school with an innovative pattern whereby one-quarter of all lectures were presented on closed-circuit television, the computer could scan the accounts and print out the benefit and cost differences.

The format of this model is sophisticated enough to deal directly with the hidden costs of unused capacity -- known to economists as "opportunity costs" -- as well as with the impact of a potential speeding up of the instruction cycle. For example, a simulation exercise involving the model shows that time-to-learn is the single most critical factor in the general cost of education. This highly significant finding is usually

overlooked in time-honored, lock-step curriculum patterns. Further, the scheduling of physical facilities for full utilization of capacity is the single most sensitive cost factor in instructional modes like CAI which depend heavily on expensive hardware.

Once again the authors of this model reiterate the importance of knowing what makes a teaching medium learning-effective and of designing appropriate instruction processes. They note the long-standing unhappiness of the Department of Defense with premature and misdirected attempts to "cost-benefit" CAI. They apologize for the fact that their own model provides methodologies only for costing, leaving one-half of the c-b problem unresolved.

Model E

Finally one might mention the c-b models covering whole universities, although here the purpose is chiefly administrative and some eons away from the mundane task of defining teaching and learning. Inputs are taken to be personnel, space, and equipment. Output is identified by developed manpower, research, and public or technical services.

Broad academic goals of higher education, and the establishment of operational measures of "quality" are explicitly put outside the scope of the model. For example, raw student credit-hours are considered a product of the university, without further inquiry into learning as such.

"Super-models" of this type measure surface phenomena, and are highly useful at the top level of administration if one could

only assume that submodels exist whose concern is the production and measurement of academic substance. In the absence of such submodels -- that is, in the absence of effective academic production controls -- such overall models of university operation may serve to institutionalize and computerize a mechanical, assembly-line type of instruction, and thus tend to dehumanize higher education.

Some Practical Considerations

The "hidden hand" that seems to push Western civilization from ritual towards reason may be perceived in an interaction between programed instruction and c-b analysis. The latter's information problem is composed of two parts:

(1) Getting hold of scientifically valid new data.

(2) In the meantime, making maximum use of existing knowledge in redesigning courses for the employment and costing of diverse media.

A most salutary influence toward a rationalization of instruction, and one whose impact has only begun to make itself felt, is programed instruction (PI). As one Army educational advisor put it, PI has caused a "cleansing" of the curriculum. What he meant was that PI required a systematic analysis of training objectives as well as materials and teaching procedures in the Army. The discipline of thinking through established teaching routines led to a sloughing off of the outmoded, the

ineffective, and the redundant. As a special bonus, the content analysis of training courses at one particular Army installation sparked new thinking about required manpower skills and caused significant changes in Military Occupational Specialties (MOS) descriptions.

This observer also credited PI with a saving in time of 30 percent, citing this figure as typical of military experience. Without however knowing the additional costs incurred through PI, plus other relevant information on its advantages and disadvantages, time savings alone do not permit valid c-b interpretations.

Some of the newer instructional media have suffered from primitive cost-benefit thinking as educators have fastened on possible cost-savings over traditional modes of instruction.

Educational television for example has sometimes been hastily and narrowly conceived as a mere money saver. The usual lecture held by the usual instructor is put on closed circuit television without much change in style or format, while most or all student contact is assumed by low-paid graduate assistants. As a result, faculties in many institutions have come to look on educational television less as an opportunity than as an economy move to exploit them. Attitudes against the spread of ETV have hardened among faculty ranks and the medium itself has become discredited.

At the other extreme, educators have been called "stick-in the mud's" who refuse to accept new technology for selfish reasons. Administrators who jump on the bandwagon and eagerly embrace any new medium that comes along presumably are "progressives." This name-calling begs the issue. A dearth of data meets any question whether the new media justify their cost relative to their productiveness. A school principal's resistance to a sales pitch and refusal to buy a "pig in a poke" may be a healthy kind of conservatism. The strongest sales argument for any piece of equipment or new production process is a careful c-b study. That is the reason why industry and the military have increasingly adopted this approach and why it is now standard fare in the modern business administration curriculum. The school must also use this approach but it has a long way to go.